(12) EUROPEAN PATENT APPLICATION

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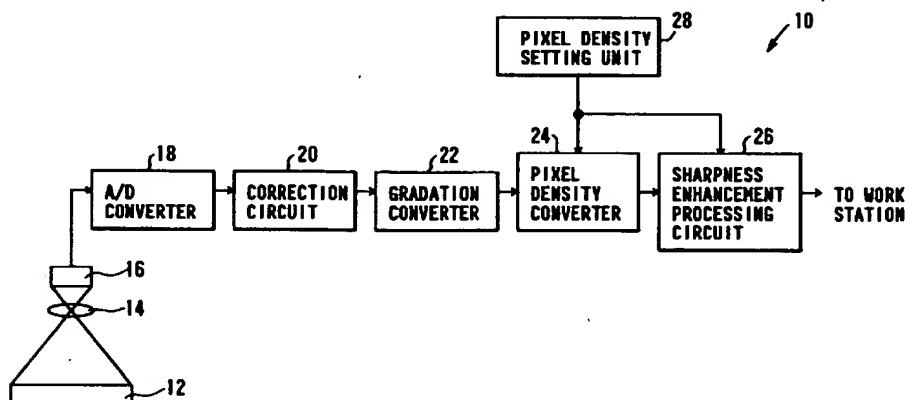Maximilianstrasse 58
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(54) **Method of and apparatus for processing image data.**

(57) Mask size data M and a sharpness enhancement coefficient K are set in accordance with the pixel density of image data S_{ij}^* to be outputted. The image data S_{ij}^* is determined as $S_{ij}^* = S_{ij} + K \cdot (S_{ij} - U_{ij})$ using the mask size data M and the sharpness enhancement coefficient K, wherein the smoothed image data U_{ij} is defined by the following equation:

$$U_{ij} = \sum_{k=i-L}^{i+L} \cdot \sum_{L=j-j_L}^{j+L} \cdot S_{kL}/M^2$$

[where L = (M−1)/2]

FIG.1

EP 0 543 386 A2

BACKGROUND OF THE INVENTION

Field of the Invention:

5   The present invention relates to a method of and an apparatus for processing image data, wherein when image data to be outputted is processed for smoothing or enhancement of sharpness, the same result of processing can be obtained at all times without depending on the pixel density, by processing the image data based on the pixel density of the outputted image data.

10   Description of the Related Art:

A system is known which causes an optical system to read image information of a copy or subject to thereby produce image data and subjects the produced image data to various image processes so as to be outputted to a printer or the like. This type of system is widely used in the printing and platemaking fields in 15   particular.

Now, a personal computer, a work station, etc. have rapidly been advanced in recent years and has come to deal even with image data. For example, characters and images have conventionally been cut and patched up by hand to produce a copy. However, DTP (Desk Top Publishing) has recently been widespread which transfers image information from an image information input/output device to a work 20   station to thereby compose the transferred image information thereat. In particular, a composing process in the printing field is effected by a composing system using the work station or the like or by a total scanner or the like.

It is sometimes necessary to effect the conversion of the pixel density of image data which is an object to be processed between the image information input/output device and the work station or the like when 25   the work station or the like is used. That is, a pixel density treatable by the image information input/output device and a pixel density treatable by the work station or the like are normally different from each other. It is therefore necessary to adjust these pixel densities.

On the other hand, the input/output device referred to above sometimes processes the image data for smoothing and enhancement of sharpness. Thus, when the conversion of the pixel density is effected upon 30   processing of the image data for smoothing and enhancement of sharpness, this results in different processes.

SUMMARY OF THE INVENTION

35   It is therefore an object of the present invention to provide a method of and an apparatus for processing image data, wherein when image data to be outputted is processed for smoothing and enhancement of sharpness, the same result of processing can be obtained at all times without depending on the pixel density of the image data.

It is another object of the present invention to provide a method of smoothing image data set and 40   outputted at a predetermined pixel density, using image data surrounding the image data, comprising the step of processing the image data for smoothness, using the surrounding image data falling within an area set so as to be substantially proportional to the predetermined pixel density.

It is a further object of the present invention to provide a method of smoothing image data, wherein the area represented by M is set so as to meet the following equation:

45

$$(1/\rho) M = C \text{ (C: constant value)}$$

where
  ρ =   pixel density
50   M =   mask size substantially proportional to the predetermined pixel density.

It is a still further object of the present invention to provide a method of smoothing image data, wherein the constant value C is set so as to fall within a range of 200 μm to 250 μm.

It is a still further object of the present invention to provide a method of smoothing image data, wherein image data S_{ij} (i = 1, ... m, j = 1, ... n) is converted into smoothed image data U_{ij} processed as defined by 55   the following equation, using M x N surrounding image data set by mask size data M, N each substantially proportional to the pixel density.

$$U_{ij} = \sum_{k=i-L}^{i+L} \cdot \sum_{L=j-P}^{j+P} \cdot S_{kL} / (L \cdot P)$$

[where L = (M − 1)/2, P = (N − 1)/2]

It is a still further object of the present invention to provide a method of processing image data S set and outputted at a predetermined pixel density for enhancement of sharpness, using image data surround − ing the image data S, comprising the steps of smoothing the image data S, using the surrounding image data falling within an area set so as to be substantially proportional to the predetermined pixel density to thereby produce smoothed image data U, and thereafter producing sharpness − enhanced image data S* represented as S* = S + K·(S − U), using the image data S, the smoothed image data U and a predetermined sharpness enhancement coefficient K.

It is a still further object of the present invention to provide a method of processing image data S set and outputted at a predetermined pixel density for enhancement of sharpness, wherein the mask size represented by M is set so as to meet the following equation:

$(1/\rho) \cdot M \doteq C$ (C: constant value)

where

ρ =   pixel density
M =   mask size substantially proportional to the predetermined pixel density.

It is a still further object of the present invention to provide a method of processing image data S set and outputted at a predetermined pixel density for enhancement of sharpness, wherein the constant value C is set so as to fall within a range of 200 μm to 250 μm.

It is a still further object of the present invention to provide a method of processing image data S set and outputted at a predetermined pixel density for enhancement of sharpness, wherein the sharpness enhancement coefficient K is set depending on the range of the surrounding image data.

It is a still further object of the present invention to provide a method of processing image data S set and outputted at a predetermined pixel density for enhancement of sharpness, wherein the relationship between the sharpness enhancement coefficient K and the mask size M is set onto a curve which passes through points close to points (K, M) = (6, 3), (2.5, 5), (1.5, 7), (1, 11).

It is a still further object of the present invention to provide a method of processing image data S set and outputted at a predetermined pixel density for enhancement of sharpness, wherein image data S_{ij} (i = 1, ... m, j = 1, ... n) is converted into smoothed image data U_{ij} processed as defined by the following equation, using M x N surrounding image data set by mask size data M, N each substantially proportional to the pixel density.

$$U_{ij} = \sum_{k=i-L}^{i+L} \cdot \sum_{L=j-P}^{j+P} \cdot S_{kL} / (L \cdot P)$$

[where L = (M − 1)/2, P = (N − 1)/2]

It is a still further object of the present invention to provide a sharpness enhancement processing apparatus for processing image data S set and outputted at a predetermined pixel density for enhancement of sharpness, using image data surrounding the image data S, comprising range-setting means for setting the area of the surrounding image data based on the predetermined pixel density, smoothed image data generating means for processing the image data S for smoothness using the surrounding image data falling within the area set by the range setting means to thereby produce smoothed image data U, and image data generating means for generating sharpness − enhanced image data S* defined as S* = S + K·(S − U), using the image data S, the smoothed image data U and a predetermined sharpness enhancement coefficient K.

It is a still further object of the present invention to provide a sharpness enhancement processing apparatus wherein the range of the surrounding image data and the sharpness enhancement coefficient K are set as a look − up table corresponding to the pixel density.

It is a still further object of the present invention to provide a sharpness enhancement processing apparatus wherein the smoothed image data generating means comprises a plurality of storing means for storing therein image data as line data arranged in a main scanning direction, selecting means for selecting image data arranged in the main scanning direction and an auxiliary scanning direction corresponding to the
5 range of the surrounding image data from the storing means, adding means for adding the selected image data together, and dividing means for dividing the added image data by the number of the selected image data.

The above and other objects, features and advantages of the present invention will become apparent from the following description and the appended claims, taken in conjunction with the accompanying
10 drawings in which a preferred embodiment of the present invention is shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic block diagram showing the structure of an image data processing apparatus
15 according to one embodiment of the present invention;
FIG. 2 is a detailed block diagram illustrating the structure of a sharpness enhancement processing circuit of the image data processing apparatus shown in FIG. 1;
FIG. 3 is a detailed block diagram depicting the structure of an auxiliary-scanning direction adding unit of the sharpness enhancement processing circuit shown in FIG. 2;
20 FIG. 4 is a view for describing a data table stored in a storage unit of the sharpness enhancement processing circuit shown in FIG. 2;
FIG. 5 is a view for describing the relationship between mask size data and sharpness enhancement coefficients shown in FIG. 4;
FIG. 6 is a view for describing image data at respective points in the auxiliary-scanning direction adding
25 unit shown in FIG. 3; and
FIG. 7 is a view for describing image data processed for enhancement of sharpness.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

30 FIG. 1 is a block diagram schematically showing the structure of an image data processing apparatus 10 according to one embodiment of the present invention. In the image data processing apparatus 10, an image recorded on a copy or subject 12 which is fed in an auxiliary scanning direction, is scanned or read in a main scanning direction by a CCD 16 via a condenser lens 14. The read image data is subjected to predetermined processing and transferred to a work station or the like. Incidentally, the work station or the
35 like processes the image data for predetermined editing and transmits the same to an output device such as a printer or the like.

The image data processing apparatus 10 comprises an A/D converter 18 for converting image data converted into an electrical signal by the CCD 16 into a digital signal, a correction circuit 20 for processing the image data converted into the digital signal for compensation for the dark current caused by the CCD
40 16, compensation for shading caused by a read optical system, etc., a gradation converter 22 for converting the gradation of the image data, a pixel density converter 24 for converting a pixel density of the image data into a pixel density processable by the work station or the like, a sharpness enhancement processing circuit 26 for processing the image data for enhancement of sharpness, and a pixel density setting unit 28 for setting a desired pixel density and for supplying data about the set pixel density to the pixel density
45 converter 24 and the sharpness enhancement processing circuit 26. Incidentally, the pixel density converter 24 effects pixel density converting processes such as an image data thinning process, an interpolating process, etc.

In the sharpness enhancement processing circuit 26, the image data is processed in principle for enhancement of sharpness in the following manner. That is, let's now consider that the image data of the
50 copy 12 comprises m pixels arranged along the main scanning direction and n pixels arranged along the auxiliary scanning direction. Further, the image data corresponding to the respective pixels is represented as S_{ij} (i = 1 ... m, j = 1 ... n). In the sharpness enhancement processing circuit 26, the image data S_{ij} is regarded as the center and M x M (M: mask size data, M ≤ m, n) image data around the image data S_{ij} are taken out along the main and auxiliary scanning directions. The image data thus taken out are the
55 smoothed, thereby producing smoothed image data U_{ij} represented as follows:

$$U_{ij} = \sum_{k=i-L}^{i+L} \cdot \sum_{L=j-L}^{j+L} \cdot S_{kL}/M^2 \qquad \cdots \quad (1)$$

[where L = (M – 1)/2]

Next, image data S_{ij}^* processed for sharpness enhancement is generated by using the image data S_{ij}, the smoothed image data U_{ij} and a given sharpness enhancement coefficient K as follows:

$$S_{ij}^* = S_{ij} + K \cdot (S_{ij} - U_{ij}) \qquad (2)$$

Incidentally, the mask size data may be processed so as to be arranged M in the main scanning direction and N in the auxiliary scanning direction (M ≠ N) upon generation of the image data S_{ij}^*. In this case, M may be set to fall between $j - P$ and $j + P$ (P = (N – 1)/2) (i.e., $j - P \le M \le j + P$ (P = (N – 1)/2) and M^2 may be set as M – N.

FIG. 2 is a block diagram showing the structure of the sharpness enhancement processing circuit 26. The sharpness enhancement processing circuit 26 comprises a CPU 30 for determining a sharpness enhancement coefficient K and mask size data M based on pixel density data ρ supplied from the pixel density setting unit 28, a storage unit 32 for storing therein the sharpness enhancement coefficient K and the mask size data M determined based on the pixel density data ρ, and a mask size controller 34 for outputting a control signal in response to the mask size data M. Further, the sharpness enhancement processing circuit 26 also includes a plurality of line memories LM1, LM2, ... LMn for storing image data therein for each main scanning line of the original 12, and selectors 36, 38 each used to store image data in a predetermined line memory LMn (n = 1, 2, ...) in response to the control signal supplied from the mask size controller 34 and to select desired image data from the predetermined line memory LMn, an auxiliary – scanning direction adding unit 40 and a main – scanning direction adding unit 42 for adding image data in the auxiliary and main scanning directions respectively to thereby generate smoothed image data U_{ij}, a multiplier 43 for multiplying image data S_{ij} outputted from the selector 38 by the square of the mask size data M, an adder 44 for adding the smoothed image data U_{ij} outputted from the main – scanning direction adding unit 42 and whose sign is inverted to data outputted from the multiplier 43, a storage unit 46 for storing a table indicative of preset image data therein, selecting predetermined image data based on the sharpness enhancement coefficient K determined by the CPU 30 and the image data outputted from the adder 44, and outputting the same therefrom, a divider 47 for dividing the image data outputted from the storage unit 46 by the square of the mask size data M determined by the CPU 30, and an adder 48 for adding image data outputted from the divider 47 to the image data S_{ij} outputted from the selector 38. Here, the adder 48 outputs S_{ij}^* and supplies it to the work station or the like.

FIG. 3 shows the configuration of the auxiliary – scanning direction adding unit 40. The auxiliary – scanning direction adding unit 40 comprises a line memory LM for storing image data supplied from the line memories LM1 through LMn as image data fed in the auxiliary scanning direction, a subtractor 50 for subtracting image data outputted from the line memory LM and whose given number of pixels is shifted, from the image data outputted from the line memories LM1 through LMn, a register 52 for temporarily storing therein image data to be outputted to the main scanning direction adding unit 42, and an adder 54 for adding the output of the subtractor 50 to the output of the register 52 so as to re – output the result of addition to the register 52.

On the other hand, the main – scanning direction adding unit 42 is constructed such that a shift register is used as an alternative to the line memory LM of the auxiliary – scanning direction adding unit 40. Other elements of structure are identical to those employed in the auxiliary – scanning direction adding unit 40, and their description will therefore be omitted.

The image data processing apparatus 10 according to the present embodiment is basically constructed as described above. The operation of the image data processing apparatus 10 will now be described below.

Image information which has been recorded on the copy 12, is first read by the CCD 16 using the condenser lens 14. The read image information is then converted into an analog signal. The converted analog signal is converted into image data serving as a digital signal by the A/D converter 18, followed by transfer to the correction circuit 20. The correction circuit 20 processes the image data for the correction relative to the dark current caused by the CCD 16, the correction of shading caused by the read optical system, etc. The gradation of the image data which has been subjected to the above processing, is converted into desired gradation in the gradation converter 22. Thereafter, the pixel density converter 24 converts the pixel density of the image data into a pixel density treatable by an external work station or the

like for effecting an editing process of the image data. Here, the pixel density converter 24 performs pixel density converting processes such as a thinning process (reduction), a linear interpolating process, an Hermite interpolating process (enlargement), etc. on the image data based on the pixel density data p outputted from the pixel density setting unit 28.

5   Next, the sharpness enhancement processing circuit 26 processes the image data subjected to the pixel density conversion for enhancement of sharpness. This process will be described in accordance with circuits shown in FIGS. 2 and 3.

The CPU 30 first reads corresponding mask size data M and a corresponding sharpness enhancement coefficient K from the storage unit 32 in response to the pixel density data p supplied from the pixel density
10 setting unit 28.

FIG. 4 shows a data table which has been stored in the storage unit 32. In FIG. 4, for example, 12 lines/mm represent pixel density data p in the case where an image is made up of 12 scanning lines per mm. The mask size data M for generating smoothed image data U, with respect to the pixel density data p is set to 3. In this case, the size of one pixel is:

15

$$1/12 \approx 83 \ \mu m \qquad (3)$$

Therefore, an output image range for producing the smoothed image data U is:

20 $$83 \times 3 = 249 \ \mu m \qquad (4)$$

Similarly, mask size data M with respect to other pixel density data p are set in such a manner that the output image range falls between 200 μm and 250 μm. That is, the mask size data M is set so as to be substantially proportional to the pixel density data p. Thus, the output image range for generating the
25 smoothed image data U is set so as to be substantially constant in the range of 200 μm to 250 μm. Therefore, a process for obtaining image data S* processed for sharpness enhancement in accordance with the equation (2) can be effected within the same output image range. Accordingly, the same result of processing can be obtained irrespective of the pixel density. Incidentally, the range of 200 μm to 250 μm represents the optimum range judging from visual characteristics of a human being.
30 FIG. 5 is a graph for describing the relationship between the mask size data M and the sharpness enhancement coefficient K. This graph shows the relationship between the mask size data M and the sharpness enhancement coefficient K for obtaining a sharpness enhancing process equivalent to that in the case where the mask size data M is set to 11 (M = 11) and the sharpness enhancement coefficient K is set to 1 (K = 1). Thus, the sharpness enhancing process depends on the sharpness enhancement coefficient K
35 as well as the mask size data M. The relationship between the pixel density data p, the mask size data M and the sharpness enhancement coefficient K is shown in the data table of FIG. 4.

The mask size data M which has been read from the storage unit 32 by the CPU 30, is supplied to the mask size controller 34 and the sharpness enhancement coefficient K is supplied to the storage unit 46. In this case, the pixel density, the mask size data M and the sharpness enhancement coefficient K will be
40 described below as being 12 lines/mm, 3 and 6, for example, respectively.

The mask size controller 34 first controls the selector 36 so as to successively connect the pixel density converter 24 (FIG. 1) to the three line memories LM1 through LM3 (because M = 3). Thus, the image data outputted from the pixel density converter 24 is stored in each of the line memories LM1 through LM3 for each main scanning line. The mask size controller 34 then controls the selector 38 so as to successively
45 output image data to the auxiliary – scanning direction adding unit 40 from the respective line memories LM1 through LM3 and so as to output the central image data S_{ij} for producing the image data S_{ij}* to the adders 44, 48 to be described later.

The auxiliary – scanning direction adding unit 40 reads image data, at the same main scanning positions, of the line memories LM1 through LM3 in the auxiliary scanning direction. Then, the read image
50 data are successively stored in the line memory LM as image data arranged in the auxiliary scanning direction and supplied to the subtractor 50 in succession. In response to the control signal outputted from the mask size controller 34, the line memory LM delays the image data a time interval corresponding to three pixels because the mask size data M is 3, and outputs the delayed image data to the subtractor 50. The output of the subtractor 50 is supplied to the register 52 via the adder 54 and added to the adder 54
55 again.

FIG. 6 shows image data at respective points (A through E) in the auxiliary – scanning direction adding unit 40 at the time that the column of image data in the main scanning direction, which are supplied from the selector 38, is represented by a through i. Incidentally, a, b, c, ... are expressed by the following

6

equations respectively:

$$\underline{a} = [S_{i-1,1}, S_{i-1,2}, \dots S_{i-1,j}, \dots S_{i-1}] \quad (5)$$

$$\underline{b} = [S_{i,1}, S_{i,2}, \dots S_{i,j}, \dots S_{i,n}] \quad (6)$$

$$\underline{c} = [S_{i+1,1}, S_{i+1,2}, \dots S_{i+1,j}, \dots S_{i+1,n}] \quad (7)$$

Here, the main – scanning direction adding unit 42 is supplied with the image data at the point E. Thus, an image data column T_i^* is outputted from the auxiliary – scanning direction adding unit 40 in accordance with the relationship shown in FIG. 6 assuming that image data S_{i-1j-1} through S_{i+1j+1} are arranged as shown in FIG. 7. The image data column T_i^* is expressed as follows:

$$
\begin{aligned}
T_i^* &= \underline{a} + \underline{b} + \underline{c} \\
&= [(S_{i-1,1} + S_{i,1} + S_{i+1,1}), \dots, \\
&\quad (S_{i-1,n} + S_{i,j} + S_{i+1,j}), \dots, \\
&\quad (S_{i-1,n} + S_{i,n} + S_{i+1,n})] \\
&= [T_{i1}^*, T_{i2}^*, \dots T_{ij}^*, \dots T_{in}^*] \quad \dots (8)
\end{aligned}
$$

where

$$T_{ij}^* = (S_{i-1j} + S_{ij} + S_{i+1j}) \quad (9)$$

Similarly, in the main – scanning direction adding unit 42, image data T_{ij} added together within a mask, i.e., in – mask added image data T_{ij} is determined by effecting serial – parallel conversion using a shift register as an alternative to the line memory LM of the auxiliary – scanning direction adding unit 40 and adding the image data T_{ij}^* in the main scanning direction. The image data T_{ij} is expressed as follows:

$$T_{ij} = (T_{ij-1}^* + T_{ij}^* + T_{ij-1}^*) \quad (10)$$

Incidentally, the relationship between the smoothed image data U_{ij} determined from the equation (1) and the in – mask added image data T_{ij} is derived as follows:

$$T_{ij} = M^2 U_{ij} \quad (11)$$

The in – mask added image data T_{ij} is then inverted. Thereafter, the adder 44 adds (actually subtracts the image data T_{ij} from data obtained by multiplying the image data S_{ij} supplied from the selector 38 to the multiplier 43 by M^2 in the multiplier 43) the image data T_{ij} to the data thus obtained, and supplies the added data to the storage unit 46. In the storage unit 46, data $K \cdot (M^2 \cdot S - T)$ is determined from the data supplied from the adder 44 and the sharpness enhancement coefficient K supplied from the CPU 30, and supplied to the divider 47. In the divider 47, the data is divided by the data M^2 supplied from the CPU 30, and the so – divided data is applied to the adder 48. Further, the adder 48 adds the image data S_{ij} to the divided data so as to produce the image data S_{ij}^* represented by the equation (2). Incidentally, the accuracy of calculation can be improved by using the image data T_{ij} defined as the equation (10) as an alternative to the smoothed image data U_{ij} defined as the equation (1).

The image data S_{ij}^* is outputted to the work station or the like, where it is subjected to a desired editing process. Here, the image data S_{ij}^* has been processed for enhancement of sharpness according to the pixel density treatable by the work station or the like. Therefore, the degree of the sharpness enhancement with respect to an image is not affected by the pixel density, and the same sharpness enhancement can be achieved at all times. .

Incidentally, a description has been made of the sharpness enhancing process in the present embodiment. However, the present embodiment can bring about the same effects even when a smoothing process (a process for obtaining the smoothed image data U) is carried out.

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According to the present invention, as has been described above, the area of image data which is of an object of either a smoothing process or a sharpness enhancing process, is set up according to the pixel density of output image data. Further, a sharpness enhancement coefficient is also set up as required. Therefore, image data which has been subjected to a given process, can be obtained without depending on the pixel density.

Having now fully described the invention, it will be apparent to those skilled in the art that many changes and modifications can be made without departing from the spirit or scope of the invention as set forth herein.

Claims

1. A method of smoothing image data set and outputted at a predetermined pixel density, using image data surrounding said image data, comprising the step of:
   processing said image data for smoothness, using said surrounding image data falling within an area set so as to be substantially proportional to said predetermined pixel density.

2. A method according to claim 1, wherein said area represented by M is set so as to meet the following equation:

   $(1/\rho)\cdot M \simeq C$ (C: constant value)

   where
   - ρ = pixel density
   - M = mask size substantially proportional to the predetermined pixel density.

3. A method according to claim 2, wherein said constant value C is set so as to fall within a range of 200 μm to 250 μm.

4. A method according to claim 1, wherein image data S_{ij} ($i = 1, \ldots m$, $j = 1, \ldots n$) is converted into smoothed image data U_{ij} processed as defined by the following equation, using M x N surrounding image data set by mask size data M, N each substantially proportional to the pixel density.

$$U_{ij} = \sum_{k=i-L}^{i+L} \cdot \sum_{L=j-P}^{j+P} \cdot S_{kL}/(L\cdot P)$$

[where $L = (M-1)/2$, $P = (N-1)/2$]

5. A method of processing image data S set and outputted in a predetermined pixel density for enhancement of sharpness, using image data surrounding said image data S, comprising the steps of:
   smoothing said image data S, using said surrounding image data falling within an area set so as to be substantially proportional to said predetermined pixel density to thereby produce smoothed image data U; and
   thereafter producing sharpness-enhanced image data S* represented as S* = S + K·(S − U), using said image data S, said smoothed image data U and a predetermined sharpness enhancement coefficient K.

6. A method according to claim 5, wherein said area represented by M is set so as to meet the following equation:

   $(1/\rho)\cdot M \simeq C$ (C: constant value)

   where
   - ρ = pixel density
   - M = mask size substantially proportional to the predetermined pixel density.

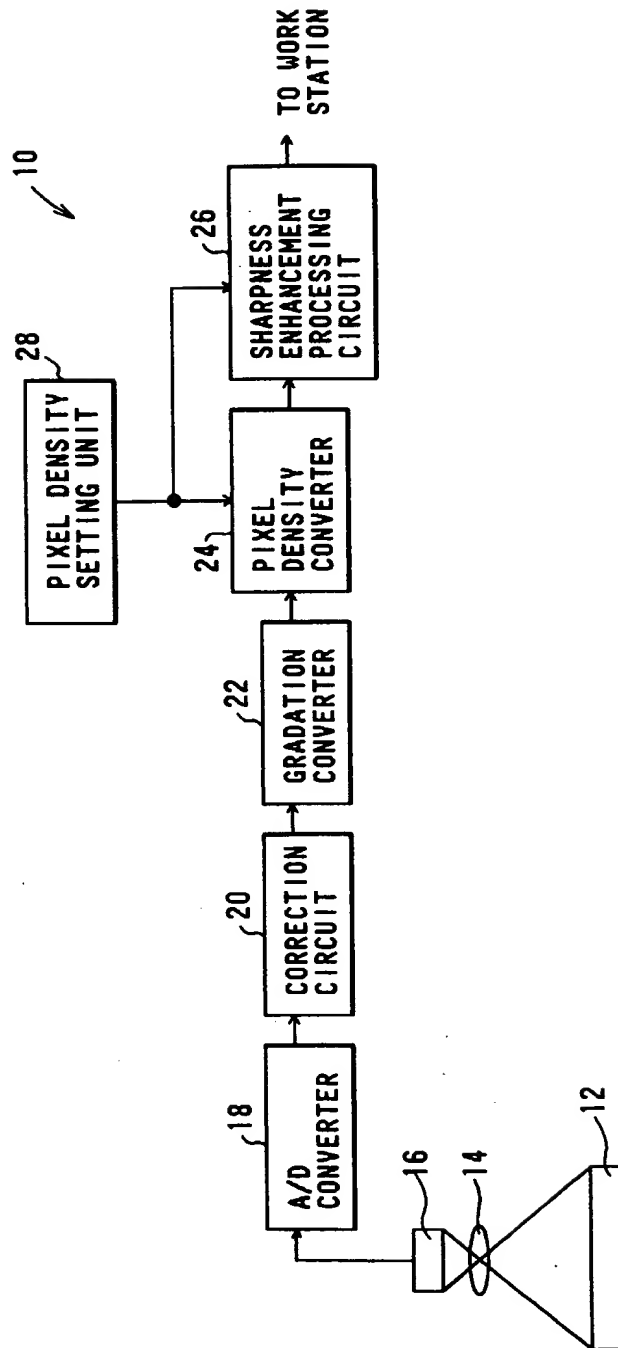7. A method according to claim 6, wherein said constant value C is set so as to fall within a range of 200 μm to 250 μm.

8. A method according to claim 5, wherein said sharpness enhancement coefficient K is set depending on the range of said surrounding image data.

9. A method according to claim 8, wherein the relationship between said sharpness enhancement coefficient K and said range M is set in accordance with a curve which passes through in the vicinity of points (K, M) = (6, 3), (2.5, 5), (1.5, 7), (1, 11).

10. A method according to claim 5, wherein image data S_{ij} (i = 1, ... m, j = 1, ... n) is converted into smoothed image data U_{ij} processed as defined by the following equation using M x N surrounding image data set by mask size data M, N each substantially proportional to the pixel density.

$$U_{ij} = \sum_{k=i-L}^{i+L} \cdot \sum_{L=j-P}^{j+P} \cdot S_{kL} / (L \cdot P)$$

[where L = (M − 1)/2, P = (N − 1/2]

11. A sharpness enhancement processing apparatus for processing image data S set and outputted in a predetermined pixel density for enhancement of sharpness, using image data surrounding said image data S, comprising:

range setting means (30) for setting the area of said surrounding image data based on said predetermined pixel density;

smoothed image data generating means (LM1~LMn, 38, 40, 42, 47) for processing said image data S for smoothness using said surrounding image data falling within the area set by said range setting means to thereby produce smoothed image data U; and

image data generating means (44, 46, 48) for generating sharpness − enhanced image data S^* defined as $S^* = S + K \cdot (S − U)$, using said image data S, said smoothed image data U and a predetermined sharpness enhancement coefficient K.

12. A sharpness enhancement processing apparatus according to claim 11, wherein the area of said surrounding image data and said sharpness enhancement coefficient K are set in a look − up table (32) corresponding to the pixel density.

13. A sharpness enhancement processing apparatus according to claim 11, wherein said smoothed image data generating means comprises a plurality of storing means (LM1~LMn) for storing therein image data as line data arranged in a main scanning direction, selecting means (38) for selecting image data arranged in the main scanning direction and an auxiliary scanning direction corresponding to the range of said surrounding image data from said storing means, adding means (40, 42) for adding said selected image data together, and dividing means (47) for dividing said added image data by the number of said selected image data.
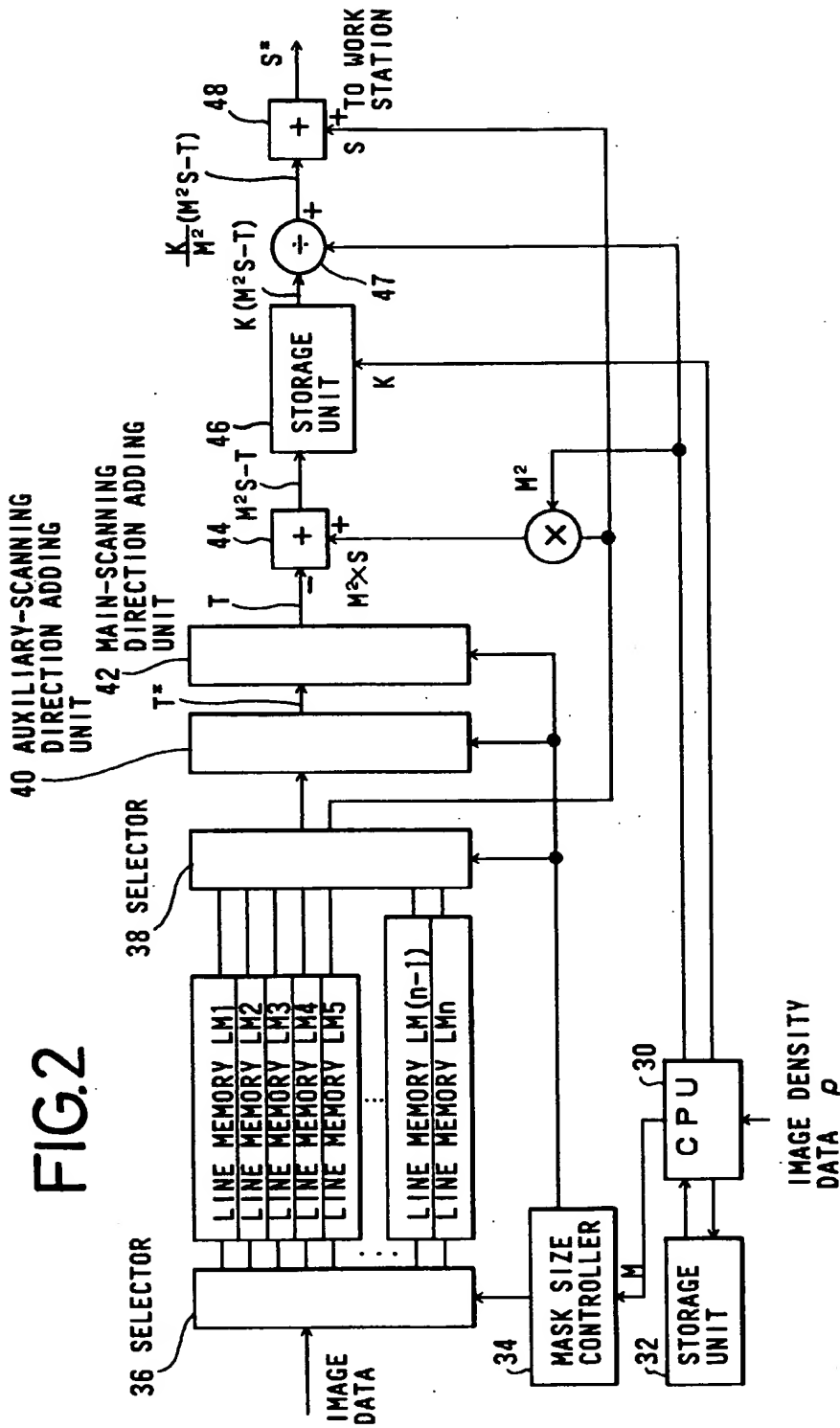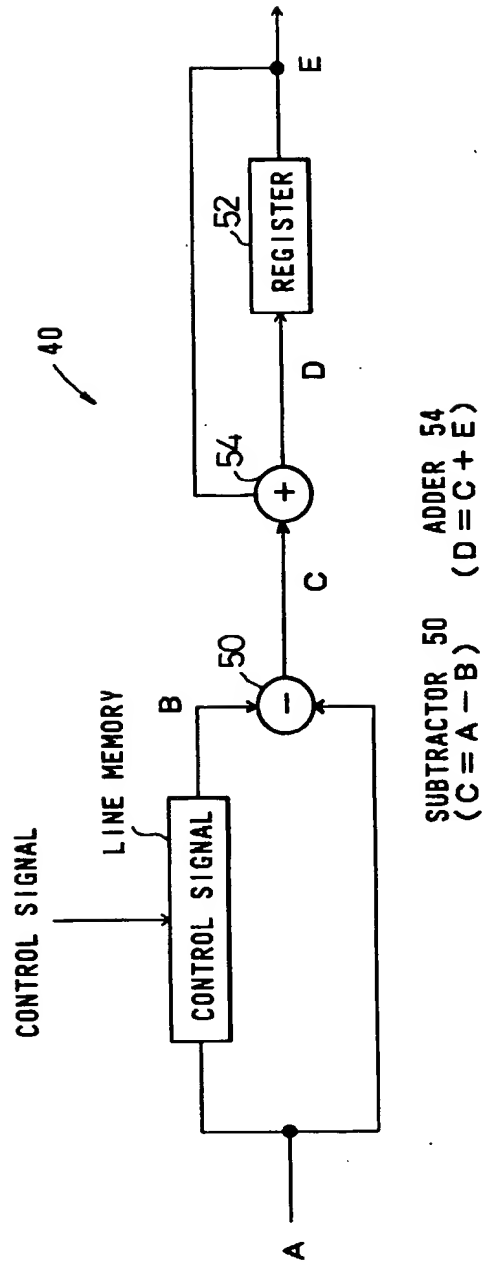
FIG.1

FIG.2

FIG.3

SUBTRACTOR 50   ADDER 54
(C=A−B)   (D=C+E)

FIG.4

PIXEL DENSITY DATA ρ	12 LINES/mm	14 LINES/mm	16 LINES/mm	24 LINES/mm	32 LINES/mm	48 LINES/mm
MASK SIZE DATA M	3	3	3	5	7	11
SHARPNESS ENHANCEMENT COEFFICIENT K	6	6	6	2.5	1.5	1

FIG.5

FIG.6

No.	A	B	C (A−B)	D (C+E)	E
1	a	0	a	a+0 = a	0
2	b	0	b	a+b = a+b	a
3	c	0	c	a+b+c = a+b+c	a+b
4	d	a	d−a	a+b+c+d−a=b+c+d	a+b+c
5	e	b	e−b	b+c+d+e−d=c+d+e	b+c+d
6	f	c	f−c	c+d+e+f−c=d+e+f	c+d+e
7	g	d	g−d	d+e+f+g−d=e+f+g	d+e+f
8	h	e	h−e	e+f+g+h−e=f+g+h	e+f+g
9	i	f	i−f	f+g+h+i−f=g+h+i	f+g+h

FIG.7

S_{i-1j-1}	S_{i-1j}	S_{i-1j+1}
S_{ij-1}	S_{ij}	S_{ij+1}
S_{i+1j-1}	S_{i+1j}	S_{i+1j+1}